Intelligent Interface Agents for Intelligent Environments

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Introduction

The utilization of immersive distributed virtual environments for military training is readily apparent (Stytz 1996; Stytz, Soltz, & Wilson 1996). These virtual environments are capable of simulating thousands of real-world and synthetic components, all interacting in real time. The user must attempt to base decisions on relevant information within the environment. However, due to the dynacism of the environment, information is difficult to locate and short-lived. Current direct manipulation human-computer interfaces are inadequate in these environments. Therefore, we must investigate new methods for enabling users to perform their tasks within these environments.

We are currently investigating the use of *interface* agents to alleviate the problem of cognitive overload in virtual environments (Banks *et al.* 1997). The driving goal of our research is to develop a comprehensive software engineering, knowledge engineering, and knowledge acquisition methodology for Symbiotic Information Reasoning and Decision Support (SIRDS). The underlying idea behind SIRDS is to allow the human to perform the tasks he/she can do well, and intelligent agents to perform the tasks they do well. Agents' strength lies in their ability to perform data acquisition and management (to include display of this information (Horvitz & Barry 1995)) from many heterogeneous sources, low level quantitative and qualitative data analysis, and routine inference to enable decision support. The human's strength lies in his/her ability to provide guidance and insight into the information that is necessary to draw complex, higher level inferences

from the data. A symbiotic approach is necessary because the objective is to let the user and the computer share the task load; therefore, we use a human-centered approach to task partitioning.

Interface Agents

Many researchers have used restricted domains (e.g., interface agents for e-mail and news readers) (Maes 1994; Bauer 1996) as application domains for their interface agents. While although the interface agents used in these domains may be adequate, scalability of the methodologies and techniques used to more complex domains, such as vitual environments, is a problem. We believe integrating intelligent interface agents into complex and dynamic environments will possibly reveal insights into interface agent research not previously recognizable with restricted domains.

One underlying problem of current interface agent research is the failure to adequately address effective and efficient knowledge representations suitable for modeling the users' interactions with the system. User modeling is concerned with how to represent users' knowledge and interaction within a system to adapt the system to the needs of users. Proliferation of user modeling as a means of accurately capturing the beliefs, abilities, and intent of users is apparent. Researchers from the fields of artificial intelligence, human-computer interaction, psychology, education, and others have all investigated ways to construct, maintain, and exploit user models. Many user models lack the representational complexity to manage the uncertainty and dynamics involved in predicting user

intent and modeling user behavior (Brown *et al.* 1997). Our current research focuses on this issue (Brown *et al.* 1998; Brown, Santos Jr., & Banks 1998). Previous work with interface agents in an expert system shell domain (Harrington, Banks, & Santos Jr. 1996a; 1996b; Harrington & Brown 1997) showed the advantage of using Bayesian Networks (Pearl 1988) to dynmaically model user behavior. We are now focusing on expanding that work by integrating utility theory and concepts from the user modeling research community (Brown, Santos Jr., & Banks 1998).

Intelligent Environments

With regards to our SIRDS approach, our interface agents must be capable of intelligent information retrieval, analysis, and presentation. Key to allowing a user to achieve his/her goals within a virtual environment is presenting the right information in the right way at the right time. The assistance the interface agent offers the user — autonomously or via user request — must support the current goals. Our utility theory-based approach as an explicit representation of users' goals within the domain, allows the interface agent to determine *when* a user is pursuing those goals and *when* and *how* to offer timely, beneficial assistance to the user.

Research in the field of intelligent interface agents for virtual environments is demonstrated by our integration into a virtual spaceplane environment (Stytz & Banks 1997). The Virtual SpacePlane (VSP) is a prototype of the Manned SpacePlane (MSP), a spacecraft capable of supporting the United States Air Force's mission of providing worldwide deployment of space assets with minimal preflight and in-orbit support from a mission control center. The goals of the VSP project are to uncover, develop and validate the MSP's user interface requirements, and develop a prototype virtual spaceplane to demonstrate MSP missions, and to conduct preliminary training experiments. The VSP environment is an accurate, high fidelity presentation of the ground, the Earth's surface as seen from orbit, and the contents of the space environment. The architectural design of the VSP allows for rapid prototyping of the cockpit's user interface and flight dynamics.

Our intelligent interface agent is currently being integrated into the VSP to support VSP assistance such as real-time information visualization of real-time data and automation of the landing sequence. Figure 1 shows the preliminary integration of the interface agent within the VSP environment. Here, the interface agent has suggested the user land at Edwards Air Force Base based on a number of observable environmental stimuli. If the user chooses to allow the agent to achieve this goal (by clicking on the "ok" button), the agent will perform the necessary actions to land the spaceplane. We are actively increasing the size of the user model by adding more goals the interface agent is predicting to prove the scalability of our interface agent architecture.

Conclusion

The use of interface agents provides a non-traditional approach to interaction within virtual environments. Our initial research shows promise in the interface agent's ability to correctly and dynamically model user intent for the purpose of assisting the user. Future efforts will progress down two avenues. First, we desire to improve the collaborative interaction between users, the virtual environment, and the interface agent. Determinination of the appropriate means for information visualization — visual or aural — is ongoing. Secondly, since knowledge acquisition continues to be the bottleneck to developing knowledge-based systems, we propose to provide tools to developers for easily constructing interface agent user models. We propose to address these issues explicitly within our development environment, while additionally concentrating on environment specification and agent knowledge base and reasoning mechanisms.

References

Banks, S. B.; Stytz, M. R.; Santos Jr., E.; and Brown, S. M. 1997. User modeling for military training: Intelligent interface agents. In *Proceedings of the 19th Interservice/Industry Training Systems and Education Conference.*

Bauer, M. 1996. Acquisition of user preferences for plan recognition. In Jameson, A.; Paris, C.; and Tasso, C., eds., *Proceedings of the Fifth Internataional Conference on User Modeling (UM '96)*, 105–112. SpringerWien, New York.

Brown, S. M.; Harrington, R. A.; Santos Jr., E.; and Banks, S. B. 1997. User models, interface agents and expert systems. In *Proceedings of the Embedding User Models in Intelligent Applications Workshop*, 12–17. held in conjunction with the Sixth International Conference on User Modeling (UM '97).

Brown, S. M.; Santos Jr., E.; Banks, S. B.; and Oxley, M. 1998. Using explicit requirements and metrics for interface agent user model correction. In *Proceedings of the Second International Conference on Autonomous Agents (Agents '98).* to appear.

Brown, S. M.; Santos Jr., E.; and Banks, S. B. 1998. Utility theory-based user models for intelligent inter-
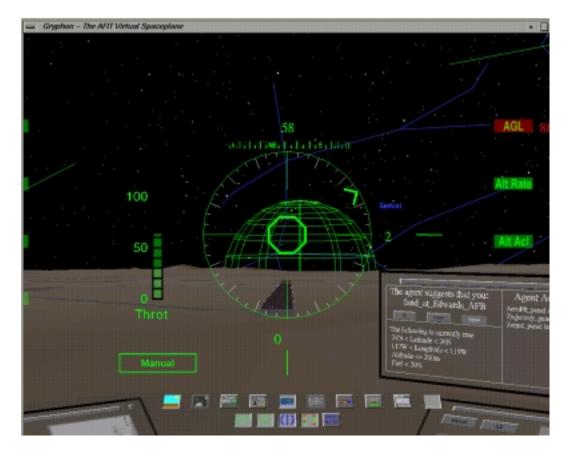
Figure 1: The Virtual SpacePlane with an Interface Agent.

face agents. In *AI '98 Twelfth Canadian Conference on Artificial Intelligence.* submitted to.

Harrington, R. A., and Brown, S. M. 1997. Intelligent interface learning with uncertainty. In Santos Jr., E., ed., *Proceedings of the Eighth Midwest Artificial Intelligence and Cognitive Science Conference*, 27–34. AAAI Press.

Harrington, R. A.; Banks, S.; and Santos Jr., E. 1996a. Development of an intelligent user interface for a generic expert system. In Gasser, M., ed., *Online Proceedings of the Seventh Midwest Artificial Intelligence and Cognitive Science Conference*. Available at http://www.cs.indiana.edu/event/maics96/.

Harrington, R. A.; Banks, S.; and Santos Jr., E. 1996b. GESIA: Uncertainty-based reasoning for a generic expert system intelligent user interface. In *Proceedings of the 8th IEEE International Conference on Tools with Artificial Intelligence*, 52–55.

Horvitz, E., and Barry, M. 1995. Display of information for time-critical decision making. In *Proceedings of the Eleventh Uncertainty in Artificial Intelligence*, 296–305.

Maes, P. 1994. Modeling adaptive autonomous agents. *Artificial Life Journal* 1(1 & 2). MIT Press (C. Langton, Ed.).

Pearl, J. 1988. *Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference.* San Mateo, CA: Morgan Kaufmann.

Stytz, M. R., and Banks, S. B. 1997. The virtual spaceplane: A modeling and simulation tool for advanced prototyping, requirements development, and training for the manned spaceplane project. In *Proceedings of the 19th Interservice/Industry Training Systems and Education Conference.*

Stytz, M. R.; Soltz, E.; and Wilson, K. 1996. The synthetic battlebridge: a tool for large-scale virtual environments. *IEEE Computer Graphics and Applications* 16(1):16–26.

Stytz, M. R. 1996. Distributed virtual environments. *IEEE Computer Graphics and Applications* 16(3):19–31.